

# Consultant's Report: Preliminary Review of Washington's Ocean Sampling Program (OSP)

F. Jay Breidt\* and Jean D. Opsomer<sup>†</sup>  
Colorado State University

Virginia Lesser<sup>‡</sup>  
Oregon State University

December 1, 2010

## 1 Introduction

During the two-day meeting in Montesano, Washington, on November 8–9, 2010, we met with Washington Department of Fish and Wildlife (WDFW) staff to discuss WDFW's Ocean Sampling Program. In this document, we will provide our initial reaction to the design and estimation procedures we learned about during the meeting.

We begin by briefly summarizing our overall reaction to OSP: it is a well-designed and executed program. The geography of the Washington coast offers distinct advantages, including a very small number of sites from which boat launches are practical. There is also limited shore and private access, so the spatial allocation of sampling effort is relatively straightforward. Anglers' required compliance with WDFW sampling efforts is another attractive feature of the program.

The program has a large and thorough sampling effort, with fine spatial and temporal stratification. The geography of sites makes it possible to obtain high-quality measures of effort, via exit counts for high-pressure sites, or

---

\*jbreidt@stat.colostate.edu.

<sup>†</sup>jopsomer@stat.colostate.edu.

<sup>‡</sup>lesser@science.oregonstate.edu

entrance counts for low-pressure sites. OSP appears to have careful design in all of its aspects, and rigorous randomization. There is also a clear and clean match between the sampling design and the estimation methods, including appropriately weighted estimates and variance estimation procedures that properly take into account the stratified, two-stage survey design. The methodology is nearly assumption-free, given its rigorous basis in probability sampling. Nevertheless, the presentation that was shown to us explicitly listed the small number of assumptions that do appear in the methodology (e.g., assuming that systematic sampling can be treated as simple random sampling). The consultants had very favorable reactions to all of these characteristics of OSP.

In the remainder of this report, we outline our recommendations for possible extensions or improvements to OSP, as well as a few suggestions for further study.

## 2 Preliminary Findings and Recommendations

### 2.1 Domain Estimation

In what follows, a “domain” is any subpopulation of interest for producing estimates, such as trip type (e.g., salmon, halibut, groundfish, other). A domain may or may not be a “stratum”, which is a subpopulation that is identifiable prior to sampling. Strata are sampled independently, with a sample size that is allocated in advance. This sample size can be treated as known (except for nonresponse issues). A “post-stratum,” on the other hand, does not have a pre-allocated sample size. It is typically not identifiable *a priori*, so the sample size in a post-stratum is an unpredictable random quantity. A post-stratum does, however, have a known population size, obtained outside the survey.

These distinctions are important when it comes to obtaining proper variance estimates for domain and population estimates. For domains that are not strata, estimates of domain means have a nonlinear (ratio) form, due to the random sample size in the denominator. Standard survey software can account for such nonlinearity if strata and domains are clearly identified. In the case of post-stratification, additional precision can be obtained from the known population information. We return to this point below.

## 2.2 Sample Size and Undercoverage Issues

For all of the major ports in the main season, OSP has a major sampling effort, dedicated to checking 20% of the landed salmon catch for coded wire tags. The data that we saw indicated that the 20% target is exceeded by a good margin. This suggests that it should be possible to reallocate some of the sampling effort to gain more information in shoulder-season months, to employ more on-board observers, and to devote more attention to known “undercoverage” issues. Undercoverage occurs when some parts of the population under study have zero probability of selection into the sample: e.g., shore mode fishing, minor ports like Tokeland and Nahcotta, or winter months. This leads to the possibility of bias in estimation of some target parameters if the “uncovered” part of the population differs from the “covered”, sampled part of the population. For an “uncovered” part of the population, there is by definition no possibility of information obtained in a sample, so only extrapolation from the covered part of the population is possible.

Even if the uncovered part of the population is similar to the covered part *now*, bias due to undercoverage can arise over time in a dynamic population. For example, while boats may almost never go out from some ports in winter *now*, this may change as anglers obtain better gear (e.g., GPS). Anglers may begin using different gear; e.g., fishing from non-standard watercraft, like kayaks and jet skis. Or anglers may target different species in the future. An example is the targeting of tuna by recreational anglers, particularly on overnight trips.

It was clear to us that WDFW staff have been continually thinking of the dynamics of this target population, and we encourage them to continue to do so. It is also clear that OSP must stop somewhere in order to define the target population. Still, we encourage them to think broadly in defining the target population and, whenever possible, to move in the direction of a full probability sample of the target population by reallocating resources beyond those needed to achieve sufficient precision for the large ports in the main season. This could be done with a relatively small reallocation of the full sampling effort.

For the specific example of overnight tuna trips, it appears that estimates may be off by substantially, because up to 50% of the trips are not recorded. Estimates might be greatly improved by reallocating sampling effort to some combination of night sampling and studying charter logbooks (either a census or a sample from a list frame of charters). This may be possible since these

trips are all leaving from one location, Westport. More generally, under-coverage issues might be addressed through some combination of reallocated sampling efforts and collection of suitable auxiliary data.

### 2.3 Auxiliary Data

There may be opportunities to include auxiliary information into the estimation procedures, to gain precision at almost no additional cost. For example, weather, bar conditions, ocean conditions, and (where relevant) river conditions may have some explanatory power for effort and catch, particularly in the off-season when other information may be difficult and costly to obtain. Note that even if regression relationships are imperfect, auxiliary data may be very useful in producing more efficient estimators using “model-assisted estimation.” Like direct survey estimates, model-assisted estimators are design-unbiased or nearly so, and allow for consistent variance estimation and proper confidence interval construction (even if the regression model is imperfect). If the regression model has reasonable explanatory power, the model-assisted estimator has smaller variance and narrower confidence intervals than the direct estimator that ignores auxiliary data.

To make things concrete, fix attention on one particular port and a given time period such as a month, and consider collecting data using the current stratified two-stage sample, but additionally recording (on the basis of weather and ocean conditions) whether the sampled day is a “good” or a “bad” fishing day. Denote the number of good sampled days at that port as  $d_{\text{good}}$  and the number of bad sampled days as  $d_{\text{bad}}$ . Next, let  $D_{\text{good}}$  denote the total number of good days (sampled or unsampled) and  $D_{\text{bad}}$  the total number of bad days for the time period, obtained by looking at external sources of information such as weather records. (If fishing was completely impossible on some days due to weather, then  $D_{\text{good}} + D_{\text{bad}} < D = \text{total number of days in the period.}$ ) Finally, let  $\hat{C}_{\text{good}}$  denote the estimated total catch on good days at the port, and  $\hat{C}_{\text{bad}}$  denote the estimated total catch on bad days. We assume that the catch on days that are not part of  $D_{\text{good}}$  and  $D_{\text{bad}}$  is zero, and for simplicity also assume that the days are sampled with equal probability. Then the post-stratified estimator of total catch at

that port and over that time period is

$$\hat{C} = D_{\text{good}} \frac{\hat{C}_{\text{good}}}{d_{\text{good}}} + D_{\text{bad}} \frac{\hat{C}_{\text{bad}}}{d_{\text{bad}}}.$$

This estimator is essentially unbiased whether or not catch on good days differs from catch on bad days. If the catch does differ, then the post-stratified estimator will have smaller variance than the estimator that ignores good versus bad. The same principles apply in more complicated situations, as long as the selection probabilities of the sampled days are known, and existing survey software can compute these estimators as well as their estimated variances.

## 2.4 Finer Stratification and Collapsed Strata Variance Estimation

One specific issue that arose in OSP was with both a primary and secondary launch site, like Neah Bay and Snow Creek in Area 4. Such sites can be divided into two strata, with different sampling rates within each. If the sampling rate drops to the level of a single site-day within stratum, then unbiased variance estimation is not possible. In this case, a standard approach is to create “collapsed strata” for the purposes of variance estimation. This simply means combining similar strata until there are at least two site-days per stratum, then treating the combined strata as if they were real strata. It can be shown that this leads to a slight overestimation of the variance, so the approximation is conservative. The greater the similarity of the combined strata, the smaller the overestimation. So, for example, if Snow Creek was sampled one day per week for each of 12 weeks, it might be sensible to combine adjacent weeks into six collapsed strata, with two days per collapsed stratum.

Collapsed strata can be used in existing statistical software for complex surveys, including the `survey` package in R or `proc surveymeans` in SAS, among others. In either case, a data set would be constructed exactly as if the collapsed strata were real strata. That is, the data would include the following elements:

- collapsed stratum identifiers

- primary sampling unit identifier: site-day (for proper two-stage variance estimation)
- sampling weight
- sampling fractions within strata (taking advantage of finite population corrections)
- response variables

## 2.5 Digital Data Recording

OSP has had the distinct advantage of a dedicated, long-term staff, including data entry specialists who transfer handwritten survey instruments to digital format. We recommend that OSP explore electronic data capture in the field, known as Computer-Assisted Personal Interviewing (CAPI). Electronic data capture speeds up data entry and editing, and can improve data quality because edits can be built into the survey instrument, allowing real-time corrections in the field. Further, both the basic data and various kinds of meta-data (like information about the data collection process) can be recorded. Electronic data capture and transfer could also make the OSP less reliant on hard-to-replace staff, like the data entry specialist with 30 years of experience. Building the expertise of staff into the design of a CAPI instrument and its edits would yield a well-documented and transferable methodology. Finally, we note that electronic data capture devices are becoming increasingly powerful, robust, and inexpensive. We list some recent references on CAPI methodology below, and there is a large body of knowledge on this topic available within the survey community:

- Gravleel, C.C. 2002. Mobile Computer-Assisted Personal Interviewing with Handheld Computers: The Entryware System 3.0. *Field Methods*, 14(3): 322-336.
- Couper, M. 2005. Technology Trends in Survey Data Collection. *Social Science Computer Review*, 23( 4): 486-501.
- Ice, G. 2004. Technological Advances in Observational Data Collection: The Advantages and Limitations of Computer-Assisted Data Collection. *Field Methods*, 16(3): 352-375.

### **3 Conclusion**

The WDFW has done an excellent job of designing and conducting OSP, as noted at the beginning of this report. It is close to a “textbook” example of an applied probability sample. The discussion in this document contains a few suggestions for improvements, some of which would require further investigation. In particular, the possible reallocation of sample to address undercoverage issues (§2.2), the use of auxiliary data to increase the precision of estimators (§2.3) and the switch to CAPI would all require further study in order to determine how to best implement them.

**Survey Review Final Status**  
**Marine Recreational Information Program**

Provider Name: **Cory Niles**

Survey: **Washington Ocean Sampling Program (OSP)**

Date of Review: **12/1/10**

Date of Final Response: **1/31/12**

**Provider Instructions:** Read the review and provide feedback if desired. Feedback includes accuracy, usefulness, and potential to implement recommendations. Comments on the review process are also welcome.

1. Accept final report:  Yes  No
  
2. Submitted MRIP proposal(s) in response to review:  Yes  No
  
3. Formal Feedback Provided:  Yes  No
  - 3a. Type of formal feedback provided:  Corrections  Comments
  
  - 3b. Corrections incorporated in final report:  Yes  No
  
  - 3c. Comments attached:  Yes  No

**Notes:**

None

## WDFW Comments on OSP Review Report

The review of OSP was a highly informative and positive experience for WDFW. Likewise, we would like to recognize MRIP and the pilot projects it has supported for the contributions it is making to the monitoring of recreational fisheries. These projects have already allowed us to conduct evaluations that we would not have been able to conduct otherwise and to make improvements about our survey programs. We look forward to future collaboration and involvement with the program. Please consider this our formal response to the preliminary report.

Answers to questions from the Operations Team to WDFW

*1. Is it possible to assess effort during fringe waves using offsite sampling methods that are potentially less expensive?*

We respond to this question by giving our best thinking on the issues involved with offseason sampling, including cost, and why we proposed the project the way we did. We are certainly open to more discussion.

First, we considered running the project with fewer samplers. Doing so would lower personnel costs, yet it also raises travel costs (we have relatively few ports to cover on the coast yet the distances between them can be surprisingly far). Overall cost would drop but not as much as one might think. More significantly, we'd be worried about the lower coverage level that would result and the risk to the project that the lower coverage would pose.

The risk comes from the "rare event" nature of what we're proposing to sample here: fishing trips are likely few and far between in the off months in Washington. As you know, with low coverage and low probably events, highly variable estimates of catch and effort are to be expected. High variance is one thing if the project is run over time and fishing patterns are relatively stable across years, yet with a one-time project like we're proposing here, that variance tells us that we'd be unlikely to achieve the project's objective. We ran a similar project some years ago with relatively low sampling coverage and are not very confident in the results. The OSP reviewers and our sampling folks agreed that this was a high priority project because of that lack of confidence (that and fishing behavior does change over time).

And, yes, there are potential offsite ways to get at the question. For example, we could look using the phone survey that we use for Puget Sound. We'd have to

design and plan and discuss this approach of course. Our initial reactions would be that the phone survey would be less expensive, yet as you know, we don't use phone surveys to get at the catch by species info. Catch by species is the main objective of this project and of OSP in general. We might also use the phone approach to get at the effort patterns and use that information to plan for the port sampling. This would be a two-year project at least, with no guarantee that we wouldn't arrive at the same answer about the necessary coverage level.

## *2. Assessing Current Sampling Allocations and Reallocating Sampling to Address Coverage Issues.*

This question was raised and discussed with the consultants during the OSP review. We are limited in our ability to reallocate sampling efforts because of other sampling requirements. There are effectively two ways to "redirect" sampling effort by decreasing current sample sizes – either we reduce the number of days sampled during the week, or we reduce the number of samplers per sampled day.

Reducing the number of sampled days per week could work during times of the year when daily fishing activity during a given week is fairly homogenous (e.g., during April or May when only bottomfishing or halibut fishing is open). However, during the July-September time period, we frequently have three or four fisheries open during a week with different closed days. For example, in Ilwaco in August, we may have a halibut fishery open on 1 weekday and 2 weekend days, an ocean salmon fishery open 4 weekdays and one weekend day, and a river salmon fishery, bottomfish fishery, and sturgeon fishery each open 7 days per week. Target trip types and catch makeup differs significantly depending on which fisheries are open on a given day. Therefore, we believe that we can't representatively cover a week if we reduce the number of days sampled during those time periods.

Reducing the number of samplers per day presents different concerns. We currently schedule samplers with the goals of (1) sampling the entire time period that boats may land, and (2) covering all potential landing areas within a port. Again, our overall goal is to give all boats on the exit or entrance count an equal chance of being included as part of the sample. Due to limited funding, each sampler we schedule in a day fills a unique temporal/spatial niche (i.e., there is little sampling overlap at the temporal/ spatial level). By reducing a

sampling team by even one sampler in a day, we remove from the potential sample boats landing in that time/location combination.

Thirdly, there are a number of “rare event” occurrences throughout the season – anything from encountering illegally retained yelloweye or canary rockfish (intensively managed species) to finding low abundance coded wire tagged salmon groups. While we typically exceed our contractual sampling obligations (a minimum 20% sample), we believe that a level of sampling higher than the contractual minimum is necessary for estimating these rare events.

Finally, funding for the Ocean Sampling Program comes from many different sources; each source has a specific associated work statement. Very few funding sources allow us the flexibility to redirect their funds to something not included in the contract, and we have specific sampling obligations that must be met. While redirecting existing sampling effort may sound easy, finding the funding to redirect that effort would be much more difficult.

### *3. Use of Auxiliary Data, such as Weather, Bar Conditions, Ocean Conditions, etc.*

This question was also raised in our review of the preliminary OSP report. Section 2.3 of that report suggests using auxiliary information on weather conditions to calculate harvest by apportioning the observed catch between good and bad weather days, then expanding each by the appropriate sampling fraction, e.g. the proportion of good weather days sampled out of the total good weather days. Before considering testing such an approach, we would like clarification of how this type of information or method would reduce bias and/or improve precision of total harvest estimates.

Under current sampling protocols, sampling days are selected at randomly a week or two prior to sampling. Good and bad weather days have equal chances of being included in the sample proportional to their occurrence, on average. There is no preference for sampling based on weather conditions under current sampling protocols and thus should be no bias (on average) in harvest or CPUE estimates based on this issue.

It is not apparent that precision would be improved by including auxiliary data in calculations of harvest. If the proportion of good and bad weather days in any week/month strata and their associated sampling fractions are a random quantities then they should be incorporated into variance calculations. Subsequently, it is unclear that post-stratification based on weather type would improve precision in harvest estimates.

We are also concerned with the potential subjectivity, inconsistency, and other logistical challenges of indexing days based on weather or ocean conditions. The benefit to precision might not outweigh the effort of the indexing or the potential for bias. Again, we are asking for further explanation on this point and are open to further discussion and consideration of employing auxiliary information in sampling.